GUAM AGRICULTURAL EXPERIMENT STATION,
ISLAND OF GUAM.

BULLETIN No. 3.

THE SORGHUMS IN GUAM.

BY

GLEN BRIGGS, Agronomist.

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[Under the supervision of the States Relations Service, United States Department of Agriculture.]

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THE SORGHUMS IN GUAM.[1]

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INTRODUCTION.

It is thought that the sorghums originated in a tropical region where they were grown for their sweet stalks and grain. In some parts of China and India they have been grown from remote historic times for their forage for live stock and their grain for man, in the latter capacity being largely used as a farinaceous food much as rice and wheat are used in other countries. The sorghums thrive on a great variety of soils and in a wide range of latitude, but they make their best growth where the prevailing temperature is high. They have splendid drought-resistant properties and supply an abundance of forage and grain at a time when other forage crops are scarce. Stockmen are unanimous in their praises of the sorghums for soiling or grain crops. For the latter use they should be particularly valuable to poultry raisers. The scarcity of insect enemies, the wide adaptability of the crops, and their relatively high yields should lead to their more extended use.

RELATION OF CLIMATE TO PRODUCTION IN GUAM.

The temperature, being strictly tropical, is conducive to the rapid growth of sorghums throughout the year. The average mean annual temperature is around 81° F. and the daily temperature ranges from about 70° to 95° F. The seasons are the wet and the dry. The sorghums are drought resistant to a very marked extent, and produce at times when other forage crops are not to be had, but the data

[1] The name "sorghum" is derived from the Latin word "surgo," meaning to tower, and was applied to the crop on account of the height it attains in comparison with that made by other crops.

on hand show that there is a close correlation between production and the amount and distribution of precipitation during the year. In the wet seasons the grain sorghums mature in a reasonably short time, but the yield is materially reduced. In the dry season the crops blossom and set grain and make large yields in the absence of rather heavy rains. The rainfall is heaviest during July, August, September, and October. During some years the rainfall is irregular both in distribution and in quantity. In general, however, comparatively little rain falls from January to May, inclusive, although light local showers occasionally occur. These are rapidly evaporated by the brisk trade winds.

The following table gives the monthly and annual rainfall for the 15-year period covering January, 1906, to December, 1920, inclusive.

Monthly and annual precipitation at Guam during the 15-year period from 1906 to 1920, inclusive.[1]

Month.	1906	1907	1908	1909	1910	1911	1912	1913
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	1.24	1.40	3.03	2.03	2.56	3.20	2.00	0.65
February	.08	(2)	.98	2.45	2.38	10.67	1.25	1.45
March	.91	2.58	.99	2.68	14.97	7.26	.68	1.00
April	2.22	2.30	1.42	1.33	3.32	.88	1.09	.70
May	.51	3.79	2.10	2.35	9.51	2.81	.65	1.30
June	2.31	5.12	4.79	5.21	3.52	8.77	2.35	2.70
July	10.13	20.15	12.48	16.07	9.97	12.64	6.10	6.85
August	5.82	14.46	12.83	9.81	7.39	19.60	20.55	15.15
September	7.99	10.15	6.99	19.09	12.55	19.13	17.00	15.15
October	13.04	8.73	13.35	14.13	12.87	15.79	14.95	15.02
November	7.44	4.73	4.38	7.70	6.78	5.60	6.15	13.35
December	3.70	3.72	3.52	9.99	4.77	1.98	9.55	7.38
Total	55.39	77.13	66.86	92.84	90.59	108.33	82.32	80.70

Month.	1914	1915	1916	1917	1918	1919	1920	Average rainfall for 15-year period.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	1.68	5.70	2.20	3.00	6.34	1.65	2.01	2.58
February	3.23	.60	6.60	1.85	6.54	.91	1.92	2.72
March	2.31	.95	.95	1.65	4.89	1.42	6.00	3.28
April	1.25	.95	3.35	1.30	2.99	.61	4.34	1.87
May	2.95	1.95	18.45	2.68	3.74	1.03	6.09	3.99
June	4.45	2.54	11.00	4.85	6.14	8.54	5.32	5.17
July	24.90	14.25	7.70	16.56	30.53	7.58	25.48	14.76
August	25.90	17.40	12.35	9.78	12.27	23.65	21.31	15.24
September	21.05	12.10	24.00	18.07	16.90	14.13	12.19	15.10
October	15.05	16.55	11.70	8.50	12.60	6.10	16.86	13.01
November	4.30	7.10	18.65	7.42	6.26	8.52	3.86	6.82
December	5.05	7.05	2.40	3.85	3.05	5.23	8.48	5.31
Total	112.12	87.14	119 35	79.51	112.25	79.37	113.86	90.52

[1] Records to July, 1917, are from the Pacific Commercial Cable Co. at Sumay. After that date they are from the Guam Agricultural Experiment Station, Piti.

[2] Record for February lost.

VARIETIES OF SORGHUMS.

The sorghums may be divided into two classes, namely, saccharine or sweet sorghums and nonsaccharine sorghums.

The sweet sorghums do well in Guam, producing large quantities of grain as well as forage. The forage is readily eaten by stock and is considered a fairly good feed. The grain is used to some extent for feeding poultry and apparently is better suited for this purpose in Guam than in the States. It is not as palatable or nutritious for stock, however, as that of the nonsaccharine sorghums. The stalks of the sweet sorghums are more juicy and contain more sugar than those of the nonsaccharine sorghums. The seed heads vary from close, compact types to the loose sorts. Varieties differ in productiveness and in the length of time required to reach maturity.

The nonsaccharine sorghums are grown both for forage and for grain, and one variety is used for making brooms and brushes. The stalks can be fed green to all classes of stock and are greatly relished by them. The nonsaccharine sorghums are generally characterized by stout stalks and pithy or semipithy stems, the juice of which varies from slightly sweet to subacid. The heads vary in compactness. Varieties having heads with short and frequent seed stems well covered with seed yield large quantities of grain. In Guam, where the humidity is high, the basal parts of heads that are very compact invariably become moldy and rotten and, if scattered through good seed at harvest time, damage the crop. On the other hand, a reasonable degree of compactness is desirable, otherwise in the succeeding crops the heads will be loose or flaring and the yield will be correspondingly reduced. Both the sweet and the nonsaccharine sorghums grow well and make heavy yields of grain during the dry season. The nonsaccharine varieties, however, are best adapted for grain production.

NONSACCHARINE SORGHUMS.

The principal nonsaccharine sorghums tested at the experiment station include Blackhull, Dwarf hegari, Red, Dawn, Sunrise, Schrock, Early, White, Yellow milo, Dwarf Yellow milo, White milo, Jerusalem corn, feterita, brown and white kaoliang, Darso, shallu, broom corn, and Sudan grass. Of this list the best grain producers have been Blackhull, Dwarf hegari, Sunrise, Dawn, Yellow milo, and feterita.

Blackhull Kafir.

The variety Blackhull is the most important of the grain sorghums that have been grown in Guam. It seems especially suitable to the climate, as it furnishes forage at a time when the pastures are short, and supplies a much-needed grain for feed. The stalks

of Blackhull kafir are erect, thick, and leafy, and produce few, if any, suckers or side branches. (Pl. I, Fig. 1.) The heads are somewhat cylindrical or club-shaped and vary from 8 to 13 inches in length, averaging nearly 10 inches. (Pl. I, Fig. 2.) The best heads are usually compact, but during the rainy season they show greater freedom of arrangement. The kernels are medium-sized, oval, or egg-shaped, and slightly flattened. The grain is white or grayish white, and has a pink spot near the tip. The hulls or glumes are black, which accounts for the name Blackhull. The seed of this variety shatters very little and thrashes out well.

Blackhull kafir attains a height of from 4.5 to 8 feet, depending upon the soil conditions and the season. The average height reached at the station is about 6 feet. This variety has matured in from 82 to 120 days after planting. The average for 15 tests made during a period of six years at the Guam station was 99.8 days for the first crop. Ratoon cuttings are made, on the average, in about 104 days. Heads appear in from 30 to 70 days after planting, depending upon the season. The average number of days, in nine tests made at the station, was 47.

Dwarf Hegari.

Dwarf hegari is the earliest as well as the most dwarf of the sorghum varieties grown at the Guam station. (Pl. II, Fig. 1.) The stalks are stout, leafy, and very erect. The heads are smaller than those of Blackhull kafir, being from 6 to 12 inches long. They are fuller in the center than at either end, are fairly compact, and shatter very little. The seed develops and matures fully because the heads are nearly all well exserted from the boot. The grain is slightly smaller than that of Blackhull kafir and has a number of tiny red spots near the tip. The glumes are grayer in appearance than those of Blackhull kafir.

The plant attains an average height of 5.2 feet, varying less in extremes than do other varieties. It shows little tendency to sucker or side branch, but after once cut it tillers in abundance. The first heads appear in about 38 days, and the whole field is fully headed about 10 days later, the heads maturing uniformly. Dwarf hegari ripens its seed in about 76 days after planting, and the first ratoon crop is harvested about 62 days later. The second ratoon crop is harvested about 70 days after the first if weather conditions are favorable. The forage is of good quality and the yield is high. Two fields planted to Dwarf hegari on July 8, 1919, yielded 19.54 and 20.41 tons, respectively, of green forage, and 100.54 and 102.11 bushels, respectively, of grain per acre for the first three cuttings, which were harvested in 208 days from date of planting.

Red Kafir.

Red kafir is similar in appearance to Blackhull kafir, but has heads that are longer, more narrow, and less compact, and stalks that are more slender than those of the latter. The seeds are pink or reddish-brown, and are partially covered by hulls that are slightly darker. During the rainy season Red kafir appeared a few days earlier than did Blackhull kafir, but during the dry season no appreciable difference was noticed in this respect. The station has experienced much difficulty in obtaining a stand of Red kafir. On account of its poor stand and low yield, the station does not recommend Red kafir.

Dawn Kafir.

Dawn kafir is a dwarf selection of Blackhull kafir, the seed of which was obtained from the United States Department of Agriculture, Washington, D. C. The stalks are slightly heavier and thicker than those of the other varieties of Blackhull kafir, but they make heavy leaf yields. The heads mature very evenly and are uniform in size and height, features which make easy the work of harvesting. The kernels are very similar in shape, size, and color to those of the other Blackhull kafirs.

In comparative tests made at the Guam station, Dawn kafir attained a height of 5.65 feet, which was only 0.92 foot less than Blackhull kafir made. During the rainy season Dawn kafir matured in 86 days, or 2.5 days later than Blackhull kafir matured. First ratoon crops of both kafirs matured in 102 days after the first crop was removed. During a test made in an extremely dry season, Dawn kafir and Dwarf Yellow milo were the only grain sorghums to yield any grain. The results obtained at the Guam station indicate Dawn kafir to be one of the most desirable varieties for planting.

Sunrise Kafir.

Seed of Sunrise kafir was introduced at the time the lot of Dawn kafir seed was received. Sunrise kafir resembles the Blackhull kafir growing at the Guam station, but has stalks that are slightly more slender and taller, and juice that is sweeter than those of the latter. The seed of Sunrise kafir ripened, on the average, in 82 days from time of planting at the station. The varieties Sunrise, Dawn, and Blackhull yielded, in a comparative test, 7.05, 8.45, and 16.01 tons, respectively, of green forage, and 5.33, 14.14, and 26.71 bushels, respectively, of grain per acre. It is only fair to state, however, that the Blackhull kafir made a better stand than did the other two varieties.

Schrock Sorghum.

Schrock sorghum, the seed of which was obtained from the Oklahoma experiment station, is another of the comparatively new sorghums. The stalks attain a height of from 7.5 to 10 feet in this humid climate, and the heads are club-shaped and not very compact. The seeds are larger than those of the ordinary Blackhull kafir, and have a brownish tinge. The heads mature in from 85 to 105 days, the average in three tests made by the Guam station being 91 days. The first ratoon crop comes on in about 80 days after the first cutting. Schrock sorghum is only a fair yielder of both forage and grain, but the forage is of good quality.

Early Kafir.

Seed of Early kafir was received from the Oklahoma experiment station in 1917. Early kafir closely resembles Blackhull kafir, but its seeds are smaller than those of the latter and its glumes are not as large nor as dark. The seeds are not as light as those of the Whitehull kafir. Early kafir seed ripened at the Guam station a few days earlier than that of Blackhull kafir, but the quality was poorer. Early kafir made fairly high yields of forage, but can not be said to possess any special characteristics which would recommend it for use in Guam.

White Kafir.

White kafir. or Whitehull kafir as it is sometimes called, is a rather early dwarf variety that is characterized by slender heads bearing somewhat flattened, white seed, and rather large, white glumes. In all tests made at the station, White kafir made poor yields of forage and very poor yields of grain. It can not be recommended for planting while other and more productive grains can be profitably grown.

Yellow Milo.

Yellow milo, or Standard milo, has been grown for a longer period than has any other grain sorghum with the possible exception of Blackhull kafir. It is characterized by medium-sized, rather pithy stems which contain less juice than those of the kafirs. The stems are leafy, however, and produce a good grade of forage, and when conditions are favorable, produce a number of suckers and side branches. The plants vary in height, but usually range from 6 to 8 feet high. Erect and pendant heads are commonly found in the same field (Pl. II, Fig. 2). The percentage of pendant heads is small, however, in strains that have been carefully selected.

The kernels of Yellow milo are large, obovate, or subcircular in outline, thick and somewhat flattened. They are reddish-yellow or

FIG. 1.—FIELD OF BLACKHULL KAFIR. PHOTOGRAPH FROM OKLAHOMA EXPERIMENT STATION.

FIG. 2.—HEADS OF BLACKHULL KAFIR. PHOTOGRAPH FROM OKLAHOMA EXPERIMENT STATION.

FIG. 1.—DWARF HEGARI.

FIG. 2.—HEADS OF MILO.

FIG. 2.—WHITE DURRA.

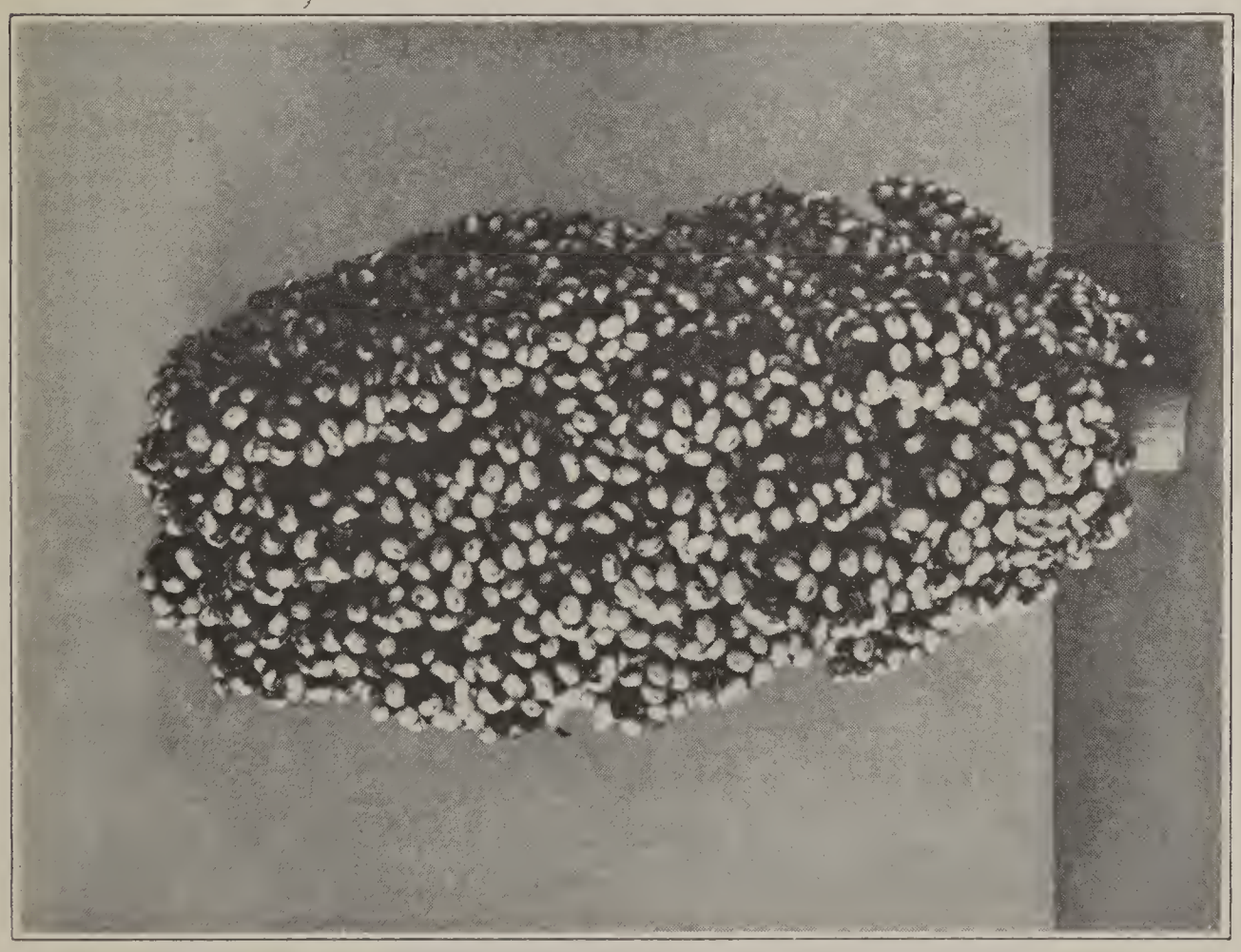

FIG. 1.—HEAD OF WHITE MILO.

FIG. 1.—FIELD OF FETERITA.

FIG. 2.—HEADS OF FETERITA.

brown, and protrude from dark yellow or brown glumes having long, crooked awns. The kernels are not only larger, but they are more brittle than those of the kafirs. For this reason they are readily masticated and digested by live stock. When Yellow milo is thinly planted it has a tendency to produce suckers and side branches. Heads that are borne on these offshoots invariably mature later than those on the main stalks, and consequently several harvestings are required to prevent a mixture of mature grain with immature kernels.

The plant matures in from 80 to 110 days depending upon weather conditions. It takes the longest time to mature during the extremely wet period. In favorable weather the first heads usually appear in about 42 days and 10 days later the whole field is out. The first ripe heads are commonly found in about 75 days after planting, and the ripening period seldom lasts more than a week or 10 days. Ratoon crops are produced in from 80 to 90 days after the preceding crop is cut. In seven tests made at the Guam station, the average yields of first crops were 7.65 tons of green forage and 15.69 bushels of grain per acre. In a planting made on newly broken land in 1919, the yield was 33.75 tons of green forage and 21.27 bushels of grain per acre from three cuttings produced in 275 days. Three crops from two plantings that were made on old soil gave an average yield in 251 days of 17.21 tons for forage and 45.95 bushels of grain per acre.

Dwarf Yellow Milo.

Dwarf milo is a small, early variety of Yellow milo. The stalks of Dwarf Yellow milo are from 18 to 30 inches shorter than those of the standard variety when they are grown under the same conditions. Dwarf Yellow milo matures several days earlier than the standard variety, but yields less in comparison owing to the small size of its heads and stalks. The heads are oval, very compact, and nearly all erect. They present a yellowish appearance due to the protrusion of a large number of the yellow seeds from the glumes. The average period between planting and harvesting is 92 days. Yields of grain have varied from 6 to more than 15 bushels per acre. This was a smaller production than was made by Blackhull kafir and feterita planted for comparative purposes.

White Milo.

White milo is characterized by slender stalks which attain a height of from 7 to 10 feet or even more. At the station the average height has been about 8 feet. The stalks produce a large number of leaves and contain considerable juice. The heads are rather short, compact, and thick (Pl. III, Fig. 1), and are borne on stems that are erect, pendant, or "goosenecked." White milo stools abundantly

and produces side branches. Its seeds are white, large, and flattened on two sides, and protrude from glumes having light-colored awns.

White milo matures fairly early, the first crop being ready for harvesting in from 70 to 110 days after planting. The average yield from four plantings was 7.98 tons of green forage per acre from the first cutting. Ratoon crops mature in from 80 to 90 days after the preceding crop is harvested. Grain yields from White milo have been about the same as those from Yellow milo, but the forage yields have been less.

White Durra.

White durra, sometimes called Jerusalem corn, was among the early station introductions (Pl. III, Fig. 2). During recent years it has been gradually replaced by better varieties of grain sorghums. The stalks of White durra are rather slender and attain a height of from 4 to 8 feet. Like most of the durras, they contain little juice and produce such a scant number of leaves as to be considered of very low value for forage purposes. A large percentage of the heads curve or turn down on the stems. They vary from 6 to 10 inches in length, and are broad, thick, egg-shaped, and fairly compact. The kernels, as well as the hairy glumes, are almost white, and are large and strongly flattened on two sides, being almost broad wedge shaped. The seed, which shatters freely when ripe, is easily lost in harvesting. The grain has been used for chicken feed with much success. Seed ripens in a comparatively short period depending upon weather conditions. The crop usually matures in from 75 to 100 days after planting. The yield is not heavy under the best of conditions. White durra has already been supplanted by other more productive varieties.

Feterita.

Feterita has given good results in nearly all tests that were made at the Guam station. The plants are medium in size, erect, and fairly leafy. The stalks, while somewhat dry, are not unpalatable to live stock. Plants grow from 6 to 8 feet and sometimes to 10 feet in height. Each separate planting makes a very uniform height (Pl. IV, Fig. 1). The heads are from 10 to 14 inches long, and taper from the center to the tip (Pl. IV, Fig. 2). They shatter slightly more than do those of the kafirs. The large seed are grayish white, strongly flattened, and bear small checked markings when they mature. The glumes vary from a light to a dark color. The seed matures very evenly and is well liked by wild birds.

Feterita is one of the early maturing grain sorghums. In eight tests conducted at the Guam station, maturity varied from 73 to 113 days, the average time being 84 days from date of planting.

The first heads appeared in less than 5 weeks and the others in from 5 to 7 weeks. The period of heading of the main crop usually extends from 12 to 16 days. The first heads ripen in about 70 to 80 days and the period of ripening extends from 12 to 30 days depending upon the amount of rain at the time. Lack of moisture hastens maturity. Ratoon crops are produced at the rate of one every 80 or 90 days.

Yields of feterita forage have been as high as 11.35 tons of green forage per acre from one cutting at the Guam station. Grain yields have ranged from 6.4 to 25.14 bushels per acre from a single crop. During 1919 the total yield for the first crop and for two ratoon crops was 18.17 tons of green forage and 46.76 bushels of grain per acre. Feterita seems to be well adapted to Guam for both forage and grain yields.

Brown Kaoliang.[2]

Brown kaoliang is one of the Chinese sorghums. The stalks are slender and dry and produce a few narrow leaves, but no suckers or side branches. They grow to a height of from 6 to 7 feet. The heads are ovate, erect, fairly compact, and from 6 to 10 inches in length. The seeds are brown, slightly flattened, and about the same size as those of kafir. The glumes are somewhat darker than is the seed.

Brown kaoliang is an early maturing variety and ripens in about three months after planting. At the station the crops have averaged about 5 tons of green forage at a cutting, and the grain yields have varied according to the season. They have never been large, however, the highest recorded grain yield from a single crop being only 14.14 bushels. Usually kaoliang does not compare favorably with kafir, feterita, or with Yellow milo in yield of forage or grain.

White Kaoliang.

White kaoliang is another of the Chinese sorghums. It differs from the brown kaoliang in that it is taller and has more open heads. Its kernels are small and ovate in comparison with the fairly large and somewhat flattened kernels of the brown kaoliang. The kernels are light or whitish and shining in appearance. The glumes are white. The plants, considering their height, bear a scant number of leaves, which are short and narrow. The slender stalks have a tendency to lodge before they mature. The forage has a low feeding value on account of the pithy and rather dry stalks. The grain yields are not large and the stalks are difficult to harvest because of their height.

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[2] "Kaoliang" is a Chinese word which means literally "tall millet."

Darso.[3]

Seed of Darso was introduced from the Oklahoma experiment station, where the variety originated and was named (Pl. V, Fig. 1). This variety has not shown the same adaptability to Guam conditions that it shows in Oklahoma. The plant is very dwarf, stocky, leafy, and of a sweeter and more juicy nature than are the other grain sorghums. It is not as sweet and juicy, however, as are the sweet sorghums. The seeds of Darso are similar to those of the Red kafir in color and size. They differ from the latter, however, in that they have a number of small wavy ridges or folds on the surface. The heads are not as compact as are those of Red kafir, and are swelled in the center and taper to the end. The heads have a tendency to poor exsertion, which feature is even more pronounced in Guam than it is in Oklahoma. The humid atmosphere of Guam often causes molding where the heads are not pushed entirely out of the boot. On this account the crop is used almost entirely for green forage.

The stalks of Darso are less than 6 feet in height. The plants mature in from 83 to 136 days at the station and averaged 102.5 days in four tests from time of planting until time of ripening of all the seed. The first heads appear in about 5 weeks, but the field does not head entirely until about 3 weeks later. The first mature heads appear in about 11 weeks under favorable conditions, and all are mature in from 12 to 13 weeks. Second ratoon crops ripen seed in from 9 to 10 weeks after the first crop is removed. Yields in dry season plantings have averaged 8.47 tons of forage per acre at the first cutting, and in wet seasons only 6.6 tons. In a planting made on July 8, three cuttings gave a total yield of 13.24 tons of green forage and 9.42 bushels of grain per acre in 232 days. It should be stated, however, that in this test the stand was estimated to be only 45 per cent of a normal stand.

Shallu.

Shallu has never given satisfactory results in any of the trials made at the Guam station, failure doubtless being due to the poor germinating qualities of the imported seed. It is a late-maturing plant and requires a long, favorable growing season, such as would seem to favor its growth in Guam. It has been widely exploited under the name of Egyptian wheat, and has gained a reputation that it can not live up to under Guam conditions.

Shallu is characterized by rather slender stalks, the pith of which is neither juicy nor sweet, and by rather large and flaring heads, which present an attractive appearance when they are filled with ripe grain. The seeds are produced on fairly long seed stems, are light in

[3] The name "Darso" is a contraction of the words "dwarf red sorghum."

FIG. 1.—HEADS OF DARSO. PHOTOGRAPH FROM OKLAHOMA EXPERIMENT STATION.

FIG. 2.—FIELD OF BROOM CORN BEFORE HEADING.

FIG. 1.—FIELD OF SUDAN GRASS.

FIG. 2.—ROOT SYSTEMS OF GRASSES. LEFT, JOHNSON GRASS; RIGHT, SUDAN GRASS.

color, being almost translucent, and are glossy, hard, and pointed at one end. The glumes or hulls are small and light, being almost straw-colored when ripe.

Broom Corn.

Broom corn is not ordinarily grown for forage because the stalks are full of pith which contains very little juice. The stalks are tall, fairly stout, and produce few leaves in proportion to their height. The seeds are produced on long seed branches in open, spreading panicles, the straw of which is used for making brooms. The plant grows from 8 to 14 feet high, and has made an average height at the Guam station of a little over 11 feet (Pl. V, Fig. 2). Broom corn matures in from 100 to 140 days, depending upon the season, and averages 123 days through wet and dry weather. First ratoon crops have ripened seed on an average of 60 days and second ratoon crops in 87 days at the station. Heads appear in 76 days after planting, and the whole field is uniformly headed in 85 days. The forage yields have been low at the Guam station, but the seed yields were fairly good. The leaves are readily eaten by live stock when the crop is harvested early, and the seed by poultry when it is mixed with other feed.

Sudan Grass (Andropogon sorghum sudanensis).

The first successful introduction of Sudan grass was made early in 1917 by the Guam station (Pl. VI, Fig. 1). Although it is strictly an annual in the States, Sudan grass has produced several cuttings covering a period of two years in Guam, and then had to be plowed up before dying.

Sudan grass is closely related to the grain sorghums and strongly resembles Johnson grass. It produces a finer but more leafy stalk than do the grain sorghums and its roots are fibrous, while Johnson grass, in addition to fibrous roots, has underground stems or rootstocks (Pl. VI, Fig. 2). Sudan grass does not grow from volunteer seedlings nor from pieces of the root, and shows no tendency to spread or persist in the field. Sudan grass is characterized by heads that are about 14 inches in length, loose, open panicles, and small, pointed seeds that vary in color from light to dark. The seed yield is low when it is compared with that of the grain sorghums, and is of little value as a feed. Sudan grass should not be planted close to the sorghums when pure seed is desired because it cross-pollinates very readily. The plants grow from 5 to 10 feet high, depending upon the season and the soil conditions. When planted in rows at the station the grass made an average height of from 7 to 8 feet. When the seed was sown broadcast the grass did not grow quite so high as when the seed was sown in rows.

The forage of Sudan grass is fed to live stock with little waste. The stems are fine and more palatable to stock than are those of the grain sorghums. The forage is relished by cattle and horses and judging from first trial results, it is thought that the grass bids fair to become another valuable soiling crop. Sudan grass may be cut for forage any time after it once becomes well established. The best time to harvest for highest quality and quantity of feed is after the grass has fully headed and before the seeds have fully developed. Harvesting somewhat later or earlier than this will not materially affect the feeding value of a green forage, however. Sudan grass makes its best growth during the season of little rainfall and equals the grain sorghums in its ability to withstand or endure drought. For this reason it is especially valuable in Guam, where it can be used as a feed to supplement the pasture grasses when their carrying capacity is reduced to a minimum by a lack of moisture.

In six tests conducted at the Guam station during the past three years, Sudan grass has yielded from 6 to 11.15 tons of green forage per acre for the first cutting and from 4.18 to 7.05 tons per acre for the second cutting. The average yield for the first cutting in the six tests was 8.5 tons, and for the second cutting 5.08 tons per acre. The length of time required to produce the crops varied from 80 to 122 days, and was dependent upon weather conditions and the stage of growth at which the grass was cut.

The ratoon crops usually do not grow to the same height as the first crops, but they produce stems that are finer and often of better quality of forage than the first crops on account of their tendency to tiller or produce a large number of shoots from the stubble. When the crop is not planted too thickly, single plants may produce as many as 100 stems. In a test begun January 6, 1917, at the Guam station, six cuttings were harvested from a single planting. The stand was damaged to such an extent by the typhoon of July 6, 1918, that it had to be destroyed. The six cuttings made a total yield of 29.41 tons of forage per acre. A comparative test of Kafir and Black Amber gave a yield of 32.80 and 47.54 tons, respectively, in six cuttings, all of which occupied the land practically for the same length of time that Sudan grass did.

Soil in which Sudan grass is grown should be well fertilized by the growing of legumes in a rotation and by the addition of manure and other fertilizers.

Johnson Grass (Andropogon halepensis).

Johnson grass, which is related to the true sorghums, was introduced about the time that the Guam station was established, roots for the initial planting being obtained from Joaquin Diaz, of Piti, who introduced it from the island of Saipan under the name of Samoa

grass. It is said that the grass was brought to Saipan from Samoa, where it had been introduced by the noted writer, Robert Louis Stevenson.

Johnson grass attains a height of from 6 to 8 feet and is characterized by stems that are erect and stiff, few leaves, and open panicles that bear small seeds varying in color from light to dark. The grass makes a most palatable and nutritious forage. It is a drought-resistant perennial and a vigorous grower, and in Guam, where there is no cold weather to check it, rapidly spreads to adjoining cultivated fields. On account of its ability to retain occupation of the soil and spread rapidly by seed and underground rootstocks, Johnson grass is considered a very obnoxious weed. In an area at the station where the land had been dug up and plowed when dry, and from which the rootstocks had been removed either by hand or with a spiketooth harrow, the growth of Johnson grass was only gradually lessened. Any small pieces of the rootstock that remain in the ground quickly start another crop. Heavy, close pasturing will keep down the growth and prevent the grass spreading from seed. Small areas can be cleared by allowing hogs to pasture the grass and to root out and eat the underground stems. The ground should then be thoroughly cultivated to keep down growth and be planted with a cultivated crop.

Nonsaccharine Sorghum Variety Tests.

The station has conducted a large number of tests with nonsaccharine sorghums but has available records only of those that have been made since 1915 (Pl. VII, Fig. 1). The following table shows the effect on yield of planting at different seasons.

Comparison of yields per acre of first crop and subsequent crops of nonsaccharine sorghums planted at different seasons.

Variety.	Date planted.	Number of days from planting to first harvest.	First crop.		Second crop.		Third crop.		Total yield.	
			Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.
			Tons.	*Bush.*	*Tons.*	*Bush.*	*Tons.*	*Bush.*	*Tons.*	*Bush.*
Blackhull kafir	July 16, 1915	91	6.25	.....	2.3	10.8	.....	.....	.....	.....
Feterita [1]	.....do.....	91	11.35	.....	9.59	.....	2.31	10.80	.....	.....
Dwarf Yellow milo	Nov. 20, 1915	88	.....	9.3	.....	.....	.....	.....	.....	.....
Feterita	.....do.....	88	.....	11.4	.....	.....	.....	.....	.....	.....
Blackhull kafir	.....do.....	106	.....	13.2	.....	.....	.....	.....	.....	.....
Dwarf Yellow milo	Dec. 1, 1915	97	.....	6.8	.....	.....	.....	.....	.....	.....
Feterita	.....do.....	97	.....	7.8	.....	.....	.....	.....	.....	.....
Blackhull kafir	.....do.....	120	.....	9.1	.....	.....	.....	.....	.....	.....
Dwarf Yellow milo	Jan. 10, 1916	92	2.81	15.7	.....	.....	.....	.....	.....	.....
Feterita	.....do.....	99	4.01	18.18	.....	.....	.....	.....	.....	.....
Blackhull kafir	.....do.....	101	3.99	23.56	.....	.....	.....	.....	.....	.....
Feterita	Jan. 27, 1916	91	2.95	.....	.....	.....	.....	.....	.....	.....
Kafir	Jan. 27, 1917	114	10.50	31.60	.....	.....	.....	.....	.....	.....

[1] Fourth crop: 5.71 tons of green forage and 9.80 bushels of grain.

Comparison of yields per acre of first crop and subsequent crops—Continued.

Variety.	Date planted.	Number of days from planting to first harvest.	First crop.		Second crop.		Third crop.		Total yield.	
			Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.
			Tons.	*Bush.*	*Tons.*	*Bush.*	*Tons.*	*Bush.*	*Tons.*	*Bush.*
Kafir [2]	Feb. 9, 1917	101	8.00	36.66	7.88	.....	3.88	.....	.....	.....
Blackhull kafir	Jan. 21, 1918 [3]	104	3.78	.....	.....	.....	.....	.....	.....	.....
Early kafir	.....do. [3]	104	5.33	.....	.....	.....	.....	.....	.....	.....
Dwarf hegari	.....do. [3]	104	5 95	.....	.....	.....	.....	.....	.....	.....
Schrock sorghum	.....do. [3]	104	8.53	.....	.....	.....	.....	.....	.....	.....
Darso	.....do. [3]	104	10.50	.....	.....	.....	.....	.....	.....	.....
Yellow milo	.....do. [3]	104	7.43	.....	.....	.....	.....	.....	.....	.....
White milo	.....do. [3]	104	10.32	.....	.....	.....	.....	.....	.....	.....
Darso	Feb. 13, 1918	136	6.43	.....	.....	.....	.....	.....	.....	.....
Schrock sorghum	.....do.....	116	7.22	.....	.....	.....	.....	.....	.....	.....
Dwarf hegari	June 14, 1919	100	11.55	[4] 15.86	3.72	6.72	2.33	17.92	17.60	40.32
Yellow milo	.....do.....	109	14.73	[4] 5.76	13.75	2.39	5.28	13.12	33.76	21.27
Blackhull kafir	.....do.....	100	4.48	[4] 3.84	13.96	.....	3.76	2.56	22.20	6.40
Feterita	.....do.....	109	3.04	[4] 6.40	10.95	7.04	7.16	29.44	21.15	42.88
White milo	.....do.....	109	5.74	[4] 3.30	10.27	.....	7.07	13.44	23.08	16.74
Broom corn	.....do.....	(5)	6.86	[4] 12.80	(5)	19.20	1.61	5.76	8.50	37.76
Do	July 8, 1919	109	7.48	3.14	.....	.....	.53	2.36	8.01	5.50
Darso	.....do.....	85	6.60	4.71	3.12	.....	3.52	4.71	13.24	9.42
Schrock sorghum	.....do.....	85	9.02	4.71	4.80	.....	4.84	12.57	18.66	17.28
Do	.....do.....	85	2.51	12.57	5.46	.....	4.05	9.43	12.02	22.00
Brown kaoliang	.....do.....	85	5.54	14.14	5.19	.....	3.34	4.71	14.07	18.85
White milo	.....do.....	79	7.88	7.85	5.90	.....	5.37	14.14	19.15	21.99
Yellow milo	.....do.....	79	7.39	31.42	7.13	4.71	3.96	11.00	18.48	47.13
Do	.....do.....	79	5.90	25.14	6.82	3.14	3.21	16.50	15.93	44.78
Feterita	.....do.....	73	4.58	25.14	6.20	5.86	4.40	19.64	15.18	50.64
Dwarf hegari	.....do.....	76	7.57	28.28	8.23	18.85	3.74	53.41	19.54	100.54
Do	.....do.....	76	6.12	43.99	10.16	18.85	4.14	39.27	20.42	102.11
Dawn kafir	.....do.....	86	.40	3.14	5.72	.....	2.33	11.00	8.45	14.14
Blackhull kafir (small seed)	.....do.....	85	2.68	14.14	7.92	.....	6.69	25.92	17.29	40.06
Blackhull kafir (large seed)	.....do.....	85	3.43	15.71	6.25	.....	4.84	7.07	14.52	22.78
Blackhull kafir	.....do.....	82	3.50	11.00	7.79	.....	4.93	6.28	16.22	17.28
Whitehull kafir	.....do.....	82	2.90	7.86	5.94	.....	3.96	5.40	12.80	13.26
White kafir	.....do.....	82	2.42	6.28	4.71	.....	1.76	11.00	8.89	17.28
Blackhull kafir	.....do.....	82	1.42	3.17	3.44	.....	2.19	2.16	7.05	5.33

[2] Fourth crop; 5.44 tons of green forage.
[3] During 1918 the grain sorghums were planted on newly broken land. The plants grew slowly and were very dwarf. They were not harvested until several days after all matured.
[4] Seed largely eaten by birds.
[5] Record lost.

SACCHARINE, OR SWEET, SORGHUMS.

The principal varieties of saccharine, or sweet, sorghums grown in Guam are (1) Black Amber; (2) Red Amber; (3) Orange; (4) Sumac; and (5) Honey.

Black Amber.

Black Amber is one of the best known varieties of the sweet sorghums. Strains of this variety are called by such names as Early Amber, Folger's Early Improved Amber, Minnesota Amber, and Black Dwarf Amber. Black Amber has slender stalks which attain a height of from 7 to 9 feet, and produce a few narrow leaves of a light color. The stems are tender, juicy, and sweet. The seed heads are open, branching, and from 8 to 12 inches long. Where

FIG. 1.—NONSACCHARINE SORGHUMS. LEFT TO RIGHT—WHITE KAFIR, DAWN KAFIR, EARLY KAFIR, BLACKHULL KAFIR, BROWN DURRA, FETERITA, SUNRISE KAFIR, SCHROCK SORGHUM, YELLOW MILO, WHITE MILO, KAOLIANG, DARSO, DWARF KAFIR.

FIG. 2.—BROOM CORN AND SWEET SORGHUMS. LEFT TO RIGHT—EARLY AMBER, HONEY, BROOM CORN, RED AMBER, ORANGE.

FIG. 1.—A WELL-PREPARED FIELD FOR SORGHUMS.

FIG. 2.—PREPARING LAND WITH SPIKE-TOOTH HARROW.

there is considerable wind, or the stalk has a tendency to lean, the heads frequently hang to one side. The small, brown seeds are almost concealed by the glumes, which are a shining black.

Black Amber is succulent and matures in from 90 to 100 days, being the earliest of the sweet sorghums. The crop ratoons in from 60 to 100 days, depending upon weather conditions. The first heads appear in about 40 or 50 days after planting and the whole field is headed within two weeks. The first ripe heads appear in from 70 to 80 days and all are ripe within 90 or 100 days when the weather is favorable. At the station, yields in five tests varied from 6 to 10 tons of green forage at the first cutting. The average yield was 8.64 tons. Seed are produced rather abundantly, one crop at the station yielding nearly 50 bushels of grain per acre. The stubble remaining after the first harvest stools freely and sometimes produces several more crops. The average yield at the station from two plantings, harvested in 255 days after planting and each producing three cuttings, was 26.02 tons of green forage and 38.84 bushels of grain per acre.

Red Amber.

Red Amber closely resembles Black Amber, but has glumes that are reddish-brown instead of shining black. It is also possibly a little more leafy than the Black Amber and matures about 10 days later. Red Amber requires from 100 to 110 days to ripen seed. The stalks average about 8 feet in height. The Amber sorghums can be cut for soiling purposes any time after they start to head, which is generally about 40 days after planting. The whole field is headed in about 55 days. A suitable stand can always be obtained when conditions are suitable because the seed germinates freely. Red Amber is drought resistant and produces forage which is relished by all kinds of live stock. In comparative tests made at the station, Red Amber produced slightly more forage per acre than did Black Amber, but the latter gave the larger yield of grain.

Orange.

Orange sorghum is characterized by seed heads or panicles that are heavier and more compact than those of the Amber sorghums. The heads are oblong, cylindrical, and rarely over 8 inches in length. The glumes, or chaff, are reddish to very dark brown at maturity and are not as long as the reddish-yellow seeds. The stalks attain a height of from 7 to 8 feet. The plant is a medium-early variety, maturing in less than 100 days when the weather is favorable. It matures very uniformly and the ripening period seldom lasts more

than 9 or 10 days. At the Guam station the Amber sorghum made larger yields than the Orange sorghum, but the quality of the latter was always good and the seed was viable when it was properly cared for.

Sumac or Redtop.

Sumac or Redtop is a stout, stocky, and very sweet variety of sorghum that produces an abundance of leaves. It is late-maturing and requires fully as long as the Honey sorghum to reach maturity. The seed heads are cylindrical, very compact, and from 6 to 8 inches long. The dark red or black glumes are hairy and shorter than the red seed which projects in such a manner as to make the whole panicle seem red. The seeds are nearly round and only about two-thirds the size of those of the other sweet sorghums. For this reason there is required a smaller quantity of Sumac than of other sweet sorghum seed to plant an acre.

Honey Sorghum.

Honey sorghum is one of the tallest, sweetest, and latest of the sorghums grown in tests for comparative purposes at the station. Its stalks are very erect and vary in height from 7 to 12 feet. Sufficient tests have not yet been conducted to determine its value as a forage crop, but it is apparently well adapted to local conditions. A poor stand and low yields were obtained from some of the plantings that were made at the end of the dry season. The first heads of Honey sorghum appeared in 80 days after planting, but the ripening period for the whole crop extended over three or four weeks.

Honey sorghum produces heads that are long, pyramidal in shape, and about twice the size of those of the Amber sorghums. They are open and spreading, and bear the seed on long stems that remain fairly erect until they reach maturity. The seeds are reddish-brown and occasionally are streaked with light markings.

Sweet Sorghum Variety Tests.

As the sweet sorghums are comparatively new in Guam, very few tests have been conducted with them, and records are available only from plantings made in 1917, 1918, and 1919. (Pl. VII, Fig. 2.) The table following gives the results of the tests made with these plantings.

FIG. 1.—COWPEAS GROWING BETWEEN ROWS OF SORGHUM.

FIG. 2.—CULTIVATION OF SORGHUM.

Comparison of yields per acre of first crop and subsequent crops of sweet sorghum planted at different seasons.[1]

Variety.	Date planted.	Number of days from planting to first harvest.	First crop.		Second crop.		Third crop.		Total yield.	
			Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.	Green forage.	Grain.
			Tons.	*Bush.*	*Tons.*	*Bush.*	*Tons.*	*Bush.*	*Tons.*	*Bush.*
Black Amber	Jan. 13, 1917	108	8.5	.....	5.92	.....	.....	.....	14.42	.....
Do	Feb. 9, 1917	101	10.5	44.6	10.41	.....	4.72	.....	25.63	44.6
Do	Jan. 21, 1918	104	8.75	.....	.....	.....	.....	.....	8.75	.....
Red Amber[2]	.....do.....	104	13.65	.....	.....	.....	.....	.....	13.65	.....
Do	June 14, 1919	109	7.43	9.60	18.80	12.80	10.20	24.96	36.43	47.36
Orange	.....do.....	109	5.37	3.84	10.94	3.84	1.61	4.48	17.92	22.16
Black Amber	.....do.....	109	9.31	20.48	15.11	.....	10.20	16.00	34.62	34.48
Orange	July 8, 1919	85	2.41	4.12	2.9	.....	2.48	10.58	7.79	14.70
Honey	.....do.....	104	.75	.....	.48	.....	.22	.....	1.45	.....
Black Amber	.....do.....	85	6.12	17.28	5.54	.....	5.76	25.92	17.42	43.20
Red Amber	.....do.....	104	10.12	4.71	6.25	.....	3.74	14.14	20.11	18.85

[1] While the Red and Black Ambers have made the highest yields in all trials, as is shown in the table, there have not been conducted a sufficient number of tests to warrant the drawing of conclusions. It is thought, however, that these two varieties will be found the most suitable of the sweet sorghums for growing in Guam.

[2] Probably miscellaneous cane.

DROUGHT RESISTANCE.

The sorghums are well adapted for growing during the dry season because they are drought resistant, not susceptible to the influence of hot winds, remain fresh and green, and produce feed when other crops have ceased growth on account of lack of moisture. Sorghums are often said to be drought resistant when they are in reality drought evaders; that is, they either mature early enough to avoid the drought, or become dormant during extremely dry periods, making little if any growth until climatic conditions become favorable. A plant is truly drought resistant when it has ability to prevent loss of water by transpiration and extract water from a dry soil. Growing plants constantly absorb water from the soil through their rootlets, and those having deeply penetrating roots naturally draw the most moisture from the soil. The extensive root system of the sorghums enable them to utilize moisture remaining in the soil after the water requirement has become too low for other crops. The ability of the sorghums to produce under conditions of little moisture or when the moisture is unevenly distributed, and to utilize the moisture to better advantage than do other crops, makes them invaluable as a forage crop in Guam.

CONDITIONS OF GROWTH.

As is true of any other cultivated crop, the sorghums make their best development when they are grown on properly prepared soil. Provided the area on which they are planted is well drained,

the sorghums will grow equally as well on good clay as on rich loam soil, and will readily adapt themselves to a soil that is easily tilled. Soils that produce corn, and even some soils that will not grow corn, oftentimes produce a fairly good crop of sorghum. Rich, sandy loam soils are retentive of moisture and more easily tilled than the finer clays and therefore are better suited for sorghum production.

It is commonly said that sorghums are "hard" on the land because by producing an enormous quantity of forage they take from the soil a correspondingly large amount of plant food. They do not remove as much fertility from the soil as does a crop of corn of equal tonnage. Apparent reduction in fertility is brought about in great measure by the physical condition in which the soil is left after the crop is harvested. Sorghums have an extensive root system and are largely surface feeders, although some of the roots do extend to a depth of 4 or more feet in the ground. The vigorous-growing roots utilize the plant food and soil moisture in a considerable area of the soil, and especially in the surface soil. When the soil is plowed the roots are thrown up in clods containing large matted pieces of the roots. In such condition, soil can not absorb or retain moisture, and if replanted without cultivation it will not produce a profitable crop. By early thorough plowing, resting the land for a reasonable length of time, and removing from it all coarse stubble, the farmer can place his ground in excellent condition for profitable production by the next crop. If sorghum is sown late with field peas or cowpeas and cut before the seeds ripen, the ground will be left in good condition, especially if it is plowed as soon as the crop is harvested.

METHODS OF CULTURE.

PREPARATION OF THE SOIL.

Sorghum seed should be planted in soil that has been thoroughly well prepared (Pl. VIII, Fig. 1). The ground should be plowed as soon as the heavy rains have ceased and while the soil is in good condition. This is usually some time in November, and depends upon the climatic conditions at that time. The soil should be plowed to a depth of 4 or 5 inches, and should be gone over with a spiketooth harrow before planting time to break the clods into small pieces and reduce the ground to a mellow condition (Pl. VIII, Fig. 2). The mellower the soil and the deeper the seed is planted the more readily will the roots develop and the better protected will the crop be from drying winds and drought influence. The land, in general, should be treated essentially as if it were being prepared for corn.

TIME AND METHOD OF PLANTING.

Sorghums may be planted at any time of the year, but they make their best growth in dry weather and usually are planted after the rainy season is past. If planted at this time the sorghums will produce two good grain crops and an abundance of forage which will be available for use during the rainy season. As a rule, little seed is produced during the rainy season, but this factor depends upon the frequency and the heaviness of the rains.

The sorghums are planted in rows from 36 to 42 inches apart, or the same distance apart that corn is planted. The crop may be planted in hills, but will stand closer planting. For this reason it is better to plant in drills, sowing the seed rather thickly in the row and later thinning the stalks to a distance of from 8 to 12 inches apart. This practice insures a good stand in the whole field. Nearly all the seed is sown by hand in furrows that are made by a small carabao plow. One and two row planters, which are equipped with special planting plates for seeds of different sizes, can be purchased on the market for sowing seed on a large scale.

When sorghum is drilled in rows, the quantity of seed required per acre varies from 3 to 6 pounds. Such a quantity will give a thick stand if the seeds are good, and will allow for thinning to the required distance when the plants are up. Planting in rows is probably the best method to follow when seed is wanted or when the crop is desired for soiling purposes. Large size in the stalks may be avoided by sowing the seed thickly in the row. From 60 to 90 pounds of seed per acre are required when broadcasting in practised. Sown broadcast, the crop does not require cultivation and can be very easily cut with a mowing machine.

Young sorghum plants grow very slowly and are not as vigorous at first as corn seedlings. The seed should therefore be planted only deep enough to insure sufficient moisture for germination and to maintain the seedling until it is able to send its roots deep into the soil. The depth of planting depends upon soil and climatic conditions, but there is not much likelihood of the seed suffering for the lack of moisture if it is sown before the dry season sets in. Seed that was planted 1 to 2 inches deep at the Guam station germinated very well under ordinary conditions. Late planting requires greater depth than early planting to insure sufficient moisture. The station advocates early planting. In one planting made in February at a depth of 2 inches, the seed did not germinate until the following May, although plantings that were made three weeks earlier produced a good crop on less than 4 inches of rainfall after the planting was made. The upper soil dries out quickly, but the subsoil is fairly retentive of moisture.

Judging from the available data for the sorghums, there is evidently a direct correlation between season or time of planting and the yield and number of days to maturity. During the wet season the sorghums mature in less time, but the yield is very materially reduced, while in the dry season, during which the crops blossom and set grain, opposite results are secured in the absence of heavy rains. The following table shows the effect of date of planting on time of maturity and yield of forage and grain.

Effect of date of planting on maturity and yield of sorghums.[1]

Date of planting.	Kafir.			Feterita.			Milo.			Black Amber.		
	Number of days to mature.	Yield.		Number of days to mature.	Yield.		Number of days to mature.	Yield.		Number of days to mature.	Yield.	
		Green forage.	Grain.		Green forage.	Grain.		Green forage.	Grain.		Green forage.	Grain.
		Tons.	*Bu.*		*Tons.*	*Bu.*		*Tons.*	*Bu.*		*Tons.*	*Bu.*
July 16, 1915:												
First crop	91	6.25	.....	91	11.35	.....	.....	.....	.....	.....	.....	.....
Ratoon crop	156	2.30	10.8	60	9.59	.....	.....	.....	.....	.....	.....	.....
Nov. 20, 1915	106	.....	13.2	88	.....	11.4	88	.....	9.3	.....	.....	.....
Dec. 1, 1915	120	.....	9.1	97	.....	7.8	97	.....	6.8	.....	.....	.....
Jan. 10, 1916	101	3.99	23.56	99	4.01	18.18	92	2.81	15.7	.....	.....	.....
Apr. 16, 1916	(2)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Jan. 13, 1917	.....	.....	.....	.....	.....	.....	.....	.....	.....	108	8.5	.....
Jan. 27, 1917	114	10.50	31.60	.....	.....	.....	.....	.....	.....	.....	.....	.....
Feb. 9, 1917	101	8.00	36.66	.....	.....	.....	.....	.....	.....	101	10.5	44.6
Jan. 21, 1918	104	3.78	.....	.....	.....	.....	104	7.43	.....	104	8.75	.....
June 14, 1919	100	4.48	3.84	109	3.04	6.40	109	14.73	5.76	109	9.31	20.48
July 8, 1919:												
First crop	85	3.43	15.71	73	4.58	25.14	79	7.39	31.42	85	6.12	17.28
First ratoon crop	102	6.25	.....	92	6.20	5.86	92	7.13	4.71	67	5.54	.....
Second ratoon crop	.....	4.84	7.07	80	4.40	19.64	80	3.96	11.00	80	5.76	25.92
Average for dry season	108	6.57	22.82	95	4.01	12.46	95	5.12	10.60	104	9.25	44.60
Average for wet season	92	3.72	6.52	91	4.74	10.51	94	11.06	12.36	97	7.71	18.88

[1] The data given in this table cover scattering tests, and for that reason are not conclusive.
[2] No grain formed in heads, probably on account of rainy weather at heading time.

PLANTING SORGHUMS WITH LEGUMES.

The sorghums may be grown in combination with cowpeas, velvet beans, or any of the other leguminous plants that grow in Guam. The latter will restore to the soil much of the nitrogen that the former removes from it. Legumes may be planted in the row with the sorghums, or between the rows at the last cultivation, or in alternate rows (Pl. IX, Fig. 1). Cowpeas and velvet beans are admirably adapted for growing with sorghums and produce a heavy vine growth which will climb upon the stalks and can be harvested with them. When fed to live stock, the sorghums should always be mixed with legumes. The former contain sugar and other fat-forming elements, and the latter, muscle-making substances, and both make a more evenly balanced ration than do either fed alone.

CULTIVATION.

Cultivation consists principally in destroying weed growth, stirring the soil so that it will be well aerated, and conserving soil moisture by reducing evaporation. The number of times that cultivation will be required depends largely upon seasonal conditions, but the yield of forage has been known to increase very materially where cultivation was judiciously practiced. The soil can largely be kept free from weeds by carefully preparing the field and by thoroughly harrowing it before planting. It is also advisable to harrow the ground after the sorghum is planted and before it comes up. Crusts that form on the surface after heavy rains should be broken with a spike-tooth harrow. Cultivation should not be done during the wet season unless a favorable period occurs and the sorghum is planted on sandy soil.

Cultivation has been done in the past largely by hand or with a fosiño. Where animal-drawn implements are used, the work is greatly facilitated. The common 5-shovel cultivator that is drawn by one animal is well adapted to conditions in Guam (Pl. IX, Fig. 2) and should be used until greater progress has been made in agricultural methods. The cultivator should be adjusted so that it will kill or cover all the weeds on the area to be cultivated. It is essential that the weeds be destroyed at the first cultivation, otherwise they will grow rapidly and be difficult to destroy at the second. The proper depth to cultivate depends upon soil conditions and the size of the plants. While the plants are small, cultivation may be fairly deep, but after they are larger the shovels of the cultivator should not reach a depth of over 3 inches because the roots are easily injured. If good work can be done at a depth of less than 3 inches, so much the better. If an ordinary 5-shovel cultivator is used, a man with a carabao can take care of a much larger area and with greater ease than is the case when hand tools are used.

HARVESTING AND THRASHING.

When the sorghums are grown for grain the heads are allowed to ripen on the stalk before the plants are harvested. The stalks remain green until they are cut, which may be long after the seed has matured. The stalks, however, have a higher feeding value when they are harvested before or about the time the seed ripens than they have when cut later. The crop is never made into hay, fodder, or silage in Guam, but is fed in the green stage as a soiling crop. The period of harvesting, therefore, is largely determined by the farmer, who cuts the crop as he needs it. When the crop is fed while the stalks are soft, tender, and succulent, there is very little if any waste.

It is customary to harvest the sorghums by hand with a machete, which seems admirably adapted for the purpose. The stalks are cut 3 to 4 inches above the ground, placed in small piles, and hauled to the animals to be fed. At the station a mower, drawn by either a bull or a carabao, is used to cut one row of stalks at a time. This is a big improvement over the hand method and is a great labor saver when large amounts of forage are required daily. No row binders or corn harvesters have been used.

When the grain is harvested for seed or for feed the heads are cut from the standing crop in the field, or after the stalks have been hauled to the feeding lot. A machete or pocket knife is used for this purpose in the field, but the machete is used only when the heads are removed after the stalks have been taken from the field. In the latter case, small bundles of stalks are placed across logs or blocks of wood and all the heads in each bundle are cut off with one blow of the machete. When ready for thrashing, the heads should be placed in a thin layer in the sun to dry for a few days. They should never be thrashed until they are thoroughly dry. Since there are no thrashing machines in Guam, the seed is thrashed by hand. When the seed is in small quantities, thrashing can be done by beating the heads against the side of a box or by pulling them through a number of nails that have been partly driven into a board for the purpose. The Guam farmer can conveniently thrash sorghum by placing the heads into a copra or other large sack[4] and beating it with a stick, turning the sack over and around until all the seed is separated from the head stems. When the seeds are in large quantities they are placed on large pandanus mats or on tarpaulins, the corners of which are tied together, and the whole is thoroughly whipped. After thrashing, one can easily pick the empty seed stems from the top of the pile, and remove the chaff, dirt, and small broken stems by winnowing the seed in the same manner that rice is winnowed.

A small thrashing machine that can be operated with a gasoline engine should be purchased by the farmer who intends to grow a large acreage year after year. These small machines will thrash and thoroughly clean the seed at one operation and do it faster and better than several men can do by hand.

RATOON CROPS.

The stubble, remaining when the sorghums are cut a short distance above the ground, suckers and produces several successive crops. The cuttings that are made after the first crop is harvested are called ratoon crops. They yield large returns for the amount of labor ex-

[4] A copra sack is an extra-large sack that is made of very heavy material. It is similar to the sacks in which coconuts are shipped to the United States.

pended upon them, if they are given proper cultivation. A comparison of successive ratoon crops grown at the station showed that the stalks had gradually lost in height and in circumference. A crop that was produced during the favorable dry weather was, however, invariably larger than the crop which was produced during the wet season.

The following table shows the comparison in yields of forage and grain from six successive cuttings of kafir, feterita, Black Amber, and Sudan grass.

Yields of successive cuttings of sorghum.

Number of cuttings.	Date of planting.	Number of days for production of crop.	Acre yield.		Total yield.	
			Green forage.	Grain.	Green forage.	Grain.
Feterita:			*Tons.*	*Bushels.*	*Tons.*	*Bushels.*
First crop	July 16, 1915	91	11.35	.....	28.96	20.60
First ratoon crop	.....do.....	62	9.79	.....		
Second ratoon crop	.....do.....	97 (329)	2.31	10.80		
Third ratoon crop	.....do.....	79	5.71	9.80		
Sudan grass:						
First crop	Jan. 6, 1917	108	9.83	.....	29.41	.....
First ratoon crop	.....do.....	122	4.18	.....		
Second ratoon crop	.....do.....	122	2.13	.....		
Third ratoon crop	.....do.....	84 (648)	3.37	.....		
Fourth ratoon crop	.....do.....	89	7.80	.....		
Fifth ratoon crop	.....do.....	123	2.10	.....		
Kafir:						
First crop	Feb. 9, 1917	101	8.00	33.60	32.80	44.10
First ratoon crop	.....do.....	86	7.80	.....		
Second ratoon crop	.....do.....	116	3.88	.....		
Third ratoon crop [1]	.....do.....	99 (625)	5.44	.....		
Fourth ratoon crop	.....do.....	95	6.46	7.50		
Fifth ratoon crop	.....do.....	128	1.14	.....		
Black Amber:						
First crop	.....do.....	101	10.50	44.60	47.54	56.90
First ratoon crop	.....do.....	86	10.41	.....		
Second ratoon crop	.....do.....	116	4.72	.....		
Third ratoon crop	.....do.....	99 (625)	7.05	.....		
Fourth ratoon crop	.....do.....	95	12.76	12.30		
Fifth ratoon crop	.....do.....	128	2.10	.....		

[1] Yield greatly reduced by animals which strayed into the field.

SELECTION OF SEED.

Only pure seed of good quality should be used for planting purposes. The sorghums cross-fertilize very readily when two or more varieties are grown close together, and the resulting plants lack uniformity in height and show variability. Considerable care should be given to the selection of sorghum seed because only a small amount is required to plant a large area. The seed should be selected in the field, where a study can be made of the relative characters of the head and the stalks as well as of the conditions under which it was grown. The grain sorghums are selected for both grain and forage production, and the sweet sorghums usually for desirable forage qualities.

Hybrids, and plants the size and character of which are due to a thin stand or to better fertilizer, should be avoided. Hybrids are

generally characterized by their large size and coarse stems, and do not reproduce true to type. Their qualities are usually the result of increased vigor due to cross-fertilization. Rigid selection should be confined to those plants which show desirable characteristics when grown under the same conditions as are the surrounding plants. The grain sorghums should be selected for uniformity of height, heads that are mature, well-shaped, fairly compact, and ripen all their seed about the same time; upright stalks and heads; freedom from shattering, suckering, and side branching; and for leafy, juicy stems which produce abundant leaves for forage. The heads should be fully exserted from the boot or upper leafsheath.

Uniformity of height permits of the removal of the heads with much less work. Dwarfness usually denotes early maturity. The heads vary in shape according to the variety. Loose, open heads give a low yield, but they are less likely to mold than are the very compact heads. When the stalks have a tendency to lodge there is likelihood of the heads coming in contact with the ground and spoiling. Pendant heads make difficult the work of harvesting, and seed that shatters freely results in the loss of large quantities of grain at harvest time. Leafy stalks are desirable because they yield a larger amount of forage than do stalks having a scant number of leaves. Suckers and side branches increase the yield of forage, but they generally mature very unevenly and produce inferior heads. A head that fails to protrude well out of the boot can not develop properly. No seed is produced in the enveloped portion, which usually becomes moldy and rotten.

The seed heads should be selected in the field before the main crop is harvested and when the crop is about half ripe. The early heads can then be readily determined and harvested before the others ripen. At the Guam station some well-filled heads, which were selected before they ripened sufficiently to mature, were marked with pasteboard tags or with pago bark, securely tied to the stem just below the head, to distinguish them at harvest time and enable them to be separated from the other seed.

In making selections from sweet sorghum varieties, more attention is given the stalk characteristics than to the head development because these sorghums are selected principally for their desirable forage qualities. Selection should be confined to stalks that are upright, slender, and supplied with numerous large, broad leaves. Most of the sweet sorghums have loose, open heads in which the seed matures very evenly. The production of a large number of stools is a desirable characteristic because they help to increase the yield of forage. A uniform, regular stand can be obtained only by rigid selection of pure, viable seed.

SEED STORAGE.

The length of time that seed can be kept depends entirely upon the dryness of the seed at time of storing and the kind of container in which it is stored. Seed may be stored in the head or after it is thrashed. When it is to be stored for any length of time the seed should be thrashed out, as in this state it requires less room than when it is stored in the head. All seed should be thoroughly dry before being stored so that it will not become moldy and unfit for feed. It should be placed in containers that are insect and moisture proof. The container should also be air-tight because of the humid atmosphere which keeps the grain damp and causes it to decay. Once weevils gain access to the container they multiply rapidly and soon destroy the seed. Many of the Guam farmers have successfully eliminated all unnecessary handling by storing their grain in metal containers that are constructed like those in use at the station. These containers or tanks are of galvanized sheet iron, the openings of which are hermetically sealed by the use of a heavy nonvolatile or slowly volatile oil. The tank is built air-tight with the exception of a single opening at the top, into which grain may be poured or through which it may be removed. When placed in such a container, seed will keep for an indefinite period.

FEEDING VALUE.

Both the forage and the grain of the sorghums have high feeding value. Chemical analyses show that the grain sorghums are very similar in composition and feeding value to corn, which is the standard used by most stockmen. Feeding tests have shown that grain of the nonsaccharine sorghums is about nine-tenths as valuable as corn; that is, nine-tenths of a bushel of corn is equal to one bushel of grain sorghum in feeding value. The seed of the sweet sorghums has a lower feeding value and on account of the large amount of tannin contained in the seed coats, is not as palatable and nutritious as that of the grain sorghums. The percentage of hulls is said to be higher in the sweet sorghums than in the grain sorghums. Sorghum seed, particularly that of grain sorghum, is one of the best poultry feeds obtainable.

Kafir forage is very comparable to that of sweet sorghums in feeding value. The forage of the other grain sorghums is sometimes inferior to these, however, and the stalks are usually not so well liked on account of their fibrous and pithy nature. The forage of all the sorghums is eaten very readily by all classes of live stock, and results from feeding it at the station have been very satisfactory.

Although no injurious effects from feeding or pasturing sorghums have ever been noted to occur in Guam, they have been reported

from other places, and in some instances the cattle have died from prussic-acid poisoning. This injurious effect has been observed to occur when the young growth has been checked by unfavorable weather conditions. Notwithstanding the nonoccurrence of poisoning, immature sorghum of checked or stunted growth should not be fed to live stock. No losses are reported to have occurred where the sorghums were fed in combination with legumes. Sorghum is an excellent forage for growing animals, and is a splendid feed for dairy cattle on account of the large flow of milk which it induces.

DISEASES OF SORGHUM.

Kernel smut (*Sphacelotheca sorghi*), which was found attacking one field of Black Amber sorghum, is the only destructive disease of sorghum that has been noted to occur. The smut damaged the heads to such an extent that the whole crop had to be destroyed and the field plowed and planted to velvet beans for several seasons. In kernel smut the individual grains are attacked and changed into masses of dark spores. The head, while retaining its usual form and outward appearance, is filled with kernels that are often twice as large as ordinary kernels. The smut can be brought under control if the seed is treated with a formaldehyde solution[5] composed of 1 pound of 40 per cent commercial formaldehyde to 40 gallons of water.

Many of the sorghums are attacked by a disease that causes the leaves to become spotted with red. After the leaves are streaked with red they frequently turn brown and die. No remedy for or means of prevention of this red spotting has been found. When sorghum is to be used for forage, it is usually cut before the disease has had a chance to injure the plant to any extent. Seed should be selected only from plants that show no sign of the disease so that a resistant variety can be developed.

Some of the sorghum plants show a yellowing or mottling of the leaves, the cause of which is unknown. This yellowing, however, is not widespread in any one field, and its damage is negligible. In 1917, W. H. Weston[6] reported that "no rust was found on sorghums [in Guam] even on the Darso variety which was most seriously damaged by this common disease in Honolulu."

INSECT PESTS OF SORGHUM.

In Guam the sorghums, while damaged to some extent by a comparatively large number of insect pests, are free from both the sorghum midge and the chinch bug, which often completely destroy

[5] For details, see U. S. Dept. Agr., Farmers' Bul. 738, p. 9.
[6] Guam Sta. Rpt. 1917, p. 55.

sorghum crops in many of the Southern States. Aphids are frequently found on young sorghum plants, but they do not injure the growing crop unless they are present in great numbers. Stored grain is frequently destroyed by weevils unless it is placed in containers that are made air-tight and insect-proof.

Probably the most destructive insect pests of growing sorghum with which the station has had to contend are (1) leaf-folders (*Marasmia trapezalis*), (2) European corn borers (*Pyrausta nubilalis*), and occasionally (3) the rice bug (*Leptocorisa varicornis*).

The leaf-folder in the larval stage binds the outer edges of the sorghum leaf together, fastening it with a sticky secretion, and feeds within the protection thus afforded. After the leaves are folded together the plant becomes distorted, loses its color, and either makes a stunted growth or dies.

The European corn borer does its greatest injury to the sorghum stalks after they have begun to head. The borer tunnels up inside the stems and severely damages the crop at certain seasons of the year. The first sign of the presence of the borers is the profrusion of frass, a sawdustlike material, from the holes inside the stalk. As the tunneling continues the head assumes a lifeless appearance and the terminal internode weakens and falls over. No remedy has been found for this pest. Where infestation has taken place the heads, after being thrashed, should be burned, together with the stalks and roots. It is also suggested that the egg clusters be collected and burned, and that the ground be given a thoroughly clean cultivation, both before and after planting.

The rice bug damages the sorghum crops only when other more desirable crops are not available to feed upon. The green forming kernels, from which the bug sucks the juice, are the parts of the plant most frequently attacked. It is suggested that the sorghum plats and adjoining field be given clean cultivation to prevent infestation, more especially since the bugs prefer rice and grassland, which afford shelter from the heat for them during the day.

SUMMARY.

The sorghums have been successfully grown for more than 15 years in Guam, where their production is not limited by temperature, but is largely dependent upon the distribution of rainfall during the year. The average annual rainfall during the 15-year period, 1906–1920, was 90.52 inches, 64 per cent of which fell during July, August, September, and October.

The sorghums will grow on a great variety of soils and in a wide range of latitudes. They make their best growth, however, on rich fertile soils and in countries where the prevailing temperature is high.

Being drought resistant, the sorghums are invaluable in Guam because they supply forage during the dry seasons, when other forage crops make poor growth.

The sorghums are divided into two great classes—the nonsaccharine sorghums and the saccharine, or sweet, sorghums. Each class is divided into groups and varieties.

Both the grain and the sweet sorghums are grown for forage, and the former kind is also grown for seed production. The stems of the latter kind are juicier and sweeter than those of the former.

Sorghums need no cultivation other than the kind usually given corn.

Most of the sorghums are harvested for soiling purposes. When the sorghums are harvested for grain, the heads are generally removed in the field, or cut off with a machete after the bundles have been hauled from the field.

Seed should be selected in the field from the standing heads of the most promising plants only. Seed is usually thrashed by hand and cleaned by winnowing in the wind. After being dried in the sun, the seed is stored in special airtight containers that are insect and moisture proof.

Ratoon crops are produced from the stubble that is left after the preceding crop has been harvested. The sorghums ratoon excellently, and as many as six crops have been secured from one planting.

In tests carried on at the station, the highest grain yields were made by Blackhull kafir, Dwarf hegari, Dawn kafir, and feterita. The highest forage yields of the nonsaccharine sorghums were made by Dwarf hegari, White milo, Schrock sorghum, and Yellow milo. The highest grain and forage yields of the sweet sorghums were made by Red Amber and Black Amber.

The feeding value of the sorghum forage is high. The forage is palatable and nutritious to all kinds of live stock, and the grain is nearly as valuable as corn as a feed, being excellently adapted for poultry.

The sorghums have very few serious enemies. They have not been seriously damaged by any disease, and only slightly at certain seasons of the year by the European corn borer, the leaf-folder, rice bugs, and weevils.

The area devoted to sorghum growing should be extended.

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